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ULTRASONIC MEASUREMENT IN FERROUS METAL

Nuraini Binti Kadir

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This Final Year Project report entitled **"ULTRASONIC MEASUREMENT IN FERROUS METAL"** was prepared by **NURAINI BINTI KADIR** as a partial fulfillment of the requirement for the Bachelor of Engineering (Hons.) Mechanical and Manufacturing Engineering is hereby read and approved by:

M.Shahril

Ir. Dr. Mohd. Shahril bin Osman

Project Supervisor

Faculty of Engineering

Universiti Malaysia Sarawak

20th MAY 2010

Date

ULTRASONIC MEASUREMENT IN FERROUS METAL

NURAINI BINTI KADIR

This project is submitted in partial fulfillment of

the requirements for the degree of Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

Faculty of Engineering

UNIVERSITI MALAYSIA SARAWAK

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Dedicated to my beloved family and friends

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ABSTRACT

In this study, thickness measurement techniques in determining the internal flaw of ferrous metal by using ultrasonic testing method were evaluated. Furthermore, the technique is non destructive technique and employs Epoch 3 ultrasonic testing equipment in determining the thickness of material. In this project work, the experiment will employ two type of sample which is metal pipe and plate metal. Sample thickness of all position then measured by using Epoch 3 ultrasonic equipment. There are significant difference existed in A-scan image between metal that contains internal flaw and metal that contains no internal flaw. Throughout the ultrasonic testing, the echoes amplitude shown in A-scan images gives improper echoes reflection whenever the flaw is detected.

ABSTRAK

Dalam kajian ini, kaedah mengukur ketebalan dalam menentukan kecacatan dalaman logam ferum dengan menggunakan ujian ultrasonik telah ditaksir. Tambahan lagi, kaedah tersebut adalah kaedah tanpa musnah dan menggunakan peralatan ujian *ultrasonic Epoch 3* dalam menentukan ketebalan bahan. Dalam kerja projek ini, eksperimen akan menggunakan dua jenis sampel iaitu paip besi dan besi leper. Ketebalan sampel di semua kedudukan kemudiannya diukur dengan menggunakan peralatan ujian *ultrasonic Epoch 3*. Perbezaan yang nyata wujud pada imej *A-scan* di antara besi yang mempunyai kecacatan dalaman dan besi yang tidak mempunyai kecacatan dalaman. Keseluruhan ujian ultrasonik, amplitud gema yang ditunjukkan dalam imej *A-scan* memberikan refleksi gema yang janggal bila-bila masa kecacatan dikesan.

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NOMENCLATURE

β	-	Beam angle
d	-	Skip distance
t	-	Thickness of the plate
α	-	Probe angle
f	-	Skip factor
D	-	Diameter
F	-	Probe factor
ASTM	-	American Society of Testing and Materials
BSI	-	British Standard Institution

CHAPTER 1

INTRODUCTION

1.0 Introduction

The ultrasonic energy has applications in various areas; this fact makes it a most fascinating subject of study. This project report is intended to highlight the scope of application in metal inspection. Ultrasonic waves and its application in non destructive testing are briefly described in this chapter.

1.1 Background of study

Ultrasonic is a mechanical vibration pressure wave similar to audible sound but the difference is that the pitch or the frequency of the vibration is much higher. Generally, the frequency range for audible sound to human is 30Hz to 15Hz whereas ultrasonic frequency is greater than about 18 kHz. This type of material testing is generally used for flaw detection or evaluation, dimensional measurement and material characterization.

Ultrasonic method is one of the non-destructive testing that is widely used for metal testing. It has been used for more many years. The used of ultrasonic technique for detecting the irregularities or flaw in solids was first proposed by Sergei Y. Sokolov in 1928. In 1931, a patent for using two ultrasonic transducers to detect flaws in solid was obtained by Mulhauser whereas in 1940, Floyd Firestone have discovered about ultrasonic pulse-echo metal flaw detection (Woo, 2006)

In 1969, a lethal accident on the busting of a 5litre oxygen cylinder occurred in Glarus without any obvious external flaw, even though the cylinder had undergone the statutory recurring water pressure test. This shows that the by just undergo water pressure test, it is not enough to prove there is no crack on the internal surface. For that reason, everyone realized the need for an improvement of routing testing (Leon, 2004). Nowadays, the ultrasonic testing was widely used for internal flaw detection, especially in critical applications such as aerospace and nuclear power due to the safety reason.

1.2 Advantages and disadvantages

As a non-destructive testing method, ultrasonic produces no potential health hazards to the inspection personnel and the tested material. Other than that, this type of material testing is less expensive than other testing method based on its ability to test without cutting out pipe. It also offers obvious advantages over its proven reliability. Ultrasonic testing provides a high level of accuracy if skillfully performed. It also requires neither system shutdown nor safety concerns during the testing (Singha, 2009). Valuable information from the test can be used for the predictions of remaining life of the tested material. This will lead to money saving by confirming that that the bad part of tested material is still suitable for decades of additional use or limit repairs to specific areas (Baldev Raj et al., 1996).

Ultrasonic testing requires extensive skill and training for the personnel to set up a test and properly interpret the results. The surface of tested material must be accessible to transmit ultrasound and it is a bit difficult to inspect materials that are rough, very small and have complex geometries. The reference standards also required for equipment calibration and characterization of flaws, this may require multiple setups (Blitz, J. and Simpson, G., 1996).

1.3 Objectives

Setting objectives of the project is important because it serves as a guide in the running of the project. Therefore, a clear understanding of the problem is needed in order to perform the required improvements on the project. The objective of this project is to determine location of crack in the ferrous metal by applying ultrasonic testing method. The scopes of the work are;

a) Employ ultrasonic test instrument to measure the metal defect and evaluate the data based on the inspection results.

b) Understand ultrasonic wave theory for measuring default in measure the metal

1.4 Ferrous metal failure

The main objective of this project is to perform the inspection of ultrasonic non destructive testing on ferrous metal which requires the study related to the causes and types of damage occurs in metal. This information will be useful in analyzing the defect found after doing the inspection.

There are several causes of pipeline failures such as material failure, construction defect, corrosion and external force. An analysis of reportable incidents of gas pipeline has been done by Giedon, D. N. and Smith R. B. to identify the most often causes of pipeline failures (Dahlberg, E.P. and Bruno,T.V., 2002). The result of the analysis is shown in Figure 1.1.

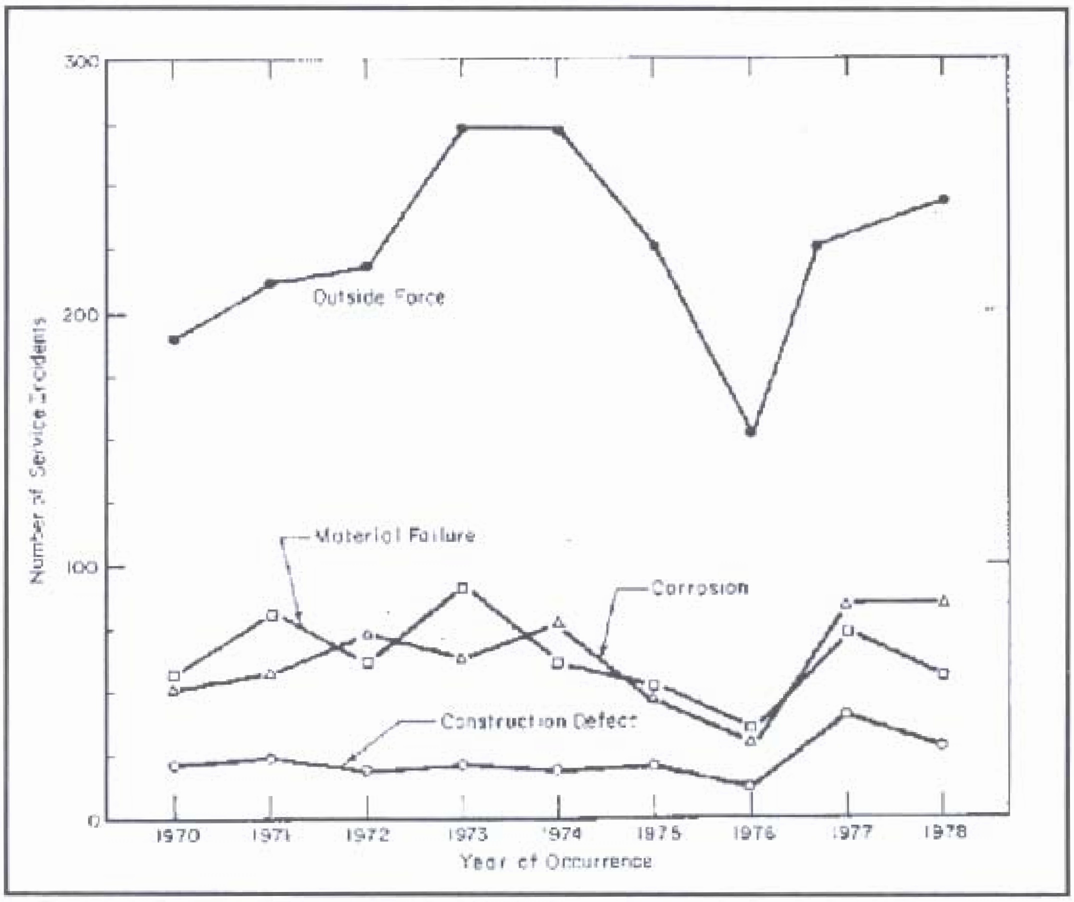

Figure 1.1: Graph of number of service incidents versus year of occurrence (Dahlberg, E.P. and Bruno,T.V., 2002)

Based on the graph in Figure 1.1, it is clearly shown that over half of all in-service pipeline failures result from some externally applied mechanical force. Whereas, the construction defect takes place as the least causes of failures. Furthermore, material defects are not common causes of service failures because they are usually found before the pipe is placed in service, either during inspection of the pipe or during hydrostatic testing (Dahlberg, E.P. and Bruno,T.V., 2002).

Externally applied mechanical force may lead to the form of gouge and dent. The combination of gouge and dent is particularly damaging and might cause rupture to the pipeline (Dahlberg, E.P. and Bruno,T.V., 2002). Gauging will damages the surface of the pipe by creating hard, brittle surface layers that have low resistance to crack initiation. Denting will change the contour of the pipe, thereby creating local areas of high strain. If the pipeline is damaged, it may fail immediately or may continue to operate for some time before failing (Bruno, 2004).

Besides, pipe damage can be introduced by fatigue cracking during pipe shipment which sometimes results from flexing the pipe during load movement (Dahlberg, E.P. and Bruno,T.V., 2002). These will subject to various kinds of loading conditions including fluctuating strain, fluctuating temperature or any of these in or without a corrosive environment. Practically all fatigue failures start at the surface or near surface. There are three stages in a fatigue failure which are crack initiation, crack propagation and fracture (Baldev Raj et al., 1996).

Corrosion also can cause failures. External corrosion in the form of pitting and general metal loss results from either coating defects, inadequate cathodic protection or both. Erosion also contributes to internal pipeline corrosion by eroding away protective scales and exposing fresh metal to attack (Bruno, 2004). Corrosion can produce failure in two ways. It may actually reduce the amount of material available to carry the load and may create small discontinuities (Baldev Raj et al., 1996). It can reduce the availability to carry the load due to the thinning of the wall over a large area or localized pitting (Dahlberg, E.P. and Bruno,T.V., 2002).

The service life of metallic materials can vary widely depends on their chemical composition, thermal treatment, mechanical working, service conditions, presence of the discontinuities and other material characteristics. In order to do the inspection, it is important for the NDT personnel to know the types of failures that might be expected and the causes for such failures. Furthermore, it will also help the NDT personnel to eliminate and assess the risk of failures.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter describes the review of the project. This literature review explores several dominant issues of the research includes the phenomena of ultrasonic waves and some important consideration on ultrasonic non-destructive testing.

2.1 Ultrasonic inspection

Ultrasonic testing is a versatile non-destructive testing method which is applicable to most materials, metallic or non metallic to accurately evaluate surface and internal discontinuities, dimensional measurements, material characterization and many more (Baldev Raj et al., 1996).

The effective use of ultrasonic energy requires an understanding of the basic principles of wave propagation and associated phenomena. Ultrasonic testing is based on vibrations in materials. Sound waves are mechanical vibrations involving movement of the medium in which they are travelling. In solids, sound waves can propagate in three basic principle mode based on the way the particles oscillate. Sound can propagate as longitudinal waves, shear waves and surface waves.

In longitudinal wave, the oscillation takes place in the longitudinal direction. The alternate compression and rarefaction zones are produced by the vibration of particles parallel to the direction of propagation of wave as shown in Figure 2.1(a). This type of wave is widely used in ultrasonic testing because of its easy generation and reception. Furthermore, this wave can propagate in solids, liquids and gases (Baldev Raj et al., 1996).

Another type of wave is transverse or shear wave as shown in Figure 2.1(b). The direction of particle displacement is at right angles or transverse to the direction of propagation. If the wave travels through a material, it is necessary that each particle of the material is strongly bounded to its neighbors. If one particle moves, it pulls its neighbor with it, thus, causing the ultrasonic energy to propagate through the material. This type of waves can only propagate in solids. This is because of the distance between molecules or atoms are so large in liquids and gases that the attractions between them are low (Baldev Raj et al., 1996).

Surface or Rayleigh waves as shown in Figure 2.1(c) is the type of waves that can travel only along a surface bounded on one side by strong elastic forces of the solid and on the other by nearly nonexistent elastic forces between gas molecules. Surface waves are not useful for testing purposes because the attenuation they suffer for a given material is lower than shear or longitudinal waves. However, the Rayleigh waves are very sensitive to surface defects and since they will follow the surface around, they can bend around corners and thus be used for testing complicated shape (Baldev Raj et al., 1996).

In plates of thickness approximately equal to one wave length, surface waves cannot exist and the ultrasonic energy travels in the form of 'Plate' and 'Lamb' waves (Baldev Raj et al., 1996).